HIGH-PRESSURE DISCHARGE LAMP

RELATED APPLICATION

[0001] This application is based on Japanese Patent Application 2003-112351, and the contents thereof are incorporated in this application by reference.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to a high-pressure discharge lamp. Specifically, the present invention relates to a high-pressure discharge lamp preferably used for lighting at such usages for high ceilings, stores, and streets.

[0003] Conventionally, high-pressure discharge lamps for such usage as high ceilings, stores, and streets. comprise a light emission tube made of quartz glass or ceramic, an outer tube, and wire frames made of a conductive material for supporting the light emission tube at the outer tube (for example, refer to U.S. Patent No. 6, 326, 721). Since the light emission tube of this kind of high-pressure discharge lamp is heated to a very high temperature during lighting, relieving the thermal stress generated in the light emission tube is critical for preventing the breakage of the light emission tube. U.S. Patent No. 6, 326, 721 discloses a structure where the stress due to the thermal expansion of the light emission tube during lighting is relieved to a coil provided at one end of the wire frame.

[0004] Further, there are other prior arts for similarly preventing the breakage of the light emission tube. In such prior arts, a compressive stress latently exerts the material of the light emission tube in advance in order to relieve the tensile stress to be generated on the surface of the light

emission tube during lighting (for example, refer to Japan Patent Application Laid-open Publication No. 2-301957 and Japan Patent Application Laid-open Publication No. 60-225159). These prior arts intend to chancel the tensile stress generated during lighting by the compressive stress latently exerted, thereby preventing the breakage of the light emission tube.

[0005] The lighting conditions required for high-pressure discharge lamps have been changing recently. The conditions are broadly classified into two conditions. As a first condition, under the circumstance where these high-pressure discharge lamps, in particular, metal halide lamps, are required to have higher efficiency, the operation pressure in the light emission tube is required to be increased from a conventional pressure of several atms (about 5 to 9 atms) to a pressure of ten-odd atms (about 10 to 15 atms) to improve lighting efficiency. Several methods are available to raise the operation pressure. For example, a general method for increasing operation pressure is to make the light emission size smaller for increasing a load applied to a tube wall and raise temperature of the light emission tube higher than a conventional temperature so as to accelerate evaporation of sealed metals. Another condition relates to the lighting posture of the lamp. Although the lamp has been used in a vertical lighting posture relatively frequently, the use of the lamp in a horizontal lighting posture is increasing in view of the design of lighting apparatuses, in particular, the design for attaining space-saving.

[0006] However, the above-mentioned prior arts are all intended to relieve the thermal stress generated in the light emission tube during

lighting at an operation pressure of several atms in a vertical lighting posture. The above-mentioned prior arts do not provide countermeasures against the thermal stress generated in the light emission tube under at a high operation pressure of ten-odd atms in a horizontal lighting posture.

SUMMARY OF THE INVENTION

[0007] An object of the present invention is to relieve the thermal stress generated in the light emission tube of a high-pressure discharge lamp. More particularly, the present invention is intended to relieve the thermal stress generated in the light emission tube at a high operation pressure of several tens of atms and in a horizontal lighting posture, thereby preventing the breakage of the high-pressure discharge lamp.

[0008] A first aspect of the present invention provides a high-pressure discharge lamp, comprising a light emission tube having a light emission portion, a pair of electrodes disposed so as to be opposed to each other in the light emission portion, and a pair of side tube portions elongating from ends of the light emission portion along an axis line connecting the electrodes, a support structure for supporting the light emission tube so as to restrict a displacement of the light emission tube at least in a direction perpendicular to the axis line, and a pair of thermal-stress generation members, base end sides of which are supported by the support structure, and the tip end sides of which are connected to the side tube portions of the light emission tube, the thermal-stress generation members generating thermal stresses by a temperature change at a time of switching the high pressure lamp from an on status to an off status, and the thermal stresses acting as forces directed downward in a vertical direction and outward with respect to the light

emission tube on the side tube portions of the light emission tube arranged in a posture where the axis line extends in a horizontal direction.

[0009] Under conditions where the lamp is used at a high operation pressure of about ten-odd atms in a horizontal lighting posture, the maximum thermal stress is generated in a vertically uppermost portion of the light emission portion by the temperature change at the time of switching the lamp from the on status to the off status. This thermal stress is a tensile stress. Because the thermal stresses generated by the thermal stress generation members act as forces directed downward in the vertical direction and outward with respect to the light emission tube on the side tube potions of the light emission tube, a compressive stress is exerted on the vertically uppermost portion of the light emission tube on which the maximum tensile stress is exerted. Therefore, the thermal-stress generation members relieve the thermal stress exerted on the light emission tube at the time of switching the lamp from the on status to the off status. This prevents the breakage or cracking of the light emission tube, resulting in that a lighting life of the high-pressure discharge lamp can be extended.

[0010] Specifically, the high-pressure discharge lamp comprises a pair of connection members for respectively connecting the side tube portions to the tip end sides of the thermal-stress generation members.

[0011] More specifically, the connection member comprises an annular portion surrounding an outer circumferential face of the side tube portion, and a fixed portion extending from the annular portion in a direction leaving away from the side tube portion, the tip side end of the thermal stress generation member being fixed to the fixed portion. The connection

member may be fixed to the side tube portion by crimping the annular portion onto the side tube portion. In this case, a groove into which the annular portion is fitted may be formed on the outer circumferential face of the side tube portion.

[0012] Where the electrodes extend in the direction of the axis line and protrude to an outside of the light emission tube through the tube portions, and where the support structure comprises wire frames for supporting the electrodes and electrically connecting the electrodes to a lighting circuit, the base ends of the pair of thermal-stress generation members may be fixed to a pair of support shafts extending respectively from the wire frames to the side tube portions.

[0013] The thermal-stress generation members are made of bimetal or a single metal material having a desired linear expansion coefficient.

[0014] The present invention is preferably applicable in the case when the light emission tube is made of a ceramic material. However, the light emission tube may also be made of other materials, such as quartz.

[0015] The present invention is preferably applicable in the case when the pressure generated by light emission substances filled in the light emission portion during lighting, that is, operation pressure, is equal to or higher than 10 MPa.

[0016] The high-pressure discharge lamp may further comprise an outer tube enclosing the light emission tube.

[0017] A second aspect of the present invention provides a high-pressure discharge lamp comprising, a light emission tube having a light emission portion, and a thermal-stress generation member for generating thermal

stress by a temperature change at a time of switching the high-pressure discharge lamp from an on status to an off status so that the thermal stress generates a compression stress in an upper portion of the light emission portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] These and other objects and features of the invention will become apparent from the following description taken in conjunction with preferred embodiments of the invention with reference to the accompanying drawings, in which:

[0019] Fig. 1 is a schematic view showing the temperature distribution of a light emission tube during lighting;

Fig. 2 is a schematic view showing the stress distribution of the light emission tube immediately after turning-off;

Fig. 3 is a schematic view showing a high-pressure discharge lamp according to an embodiment of the present invention;

Fig. 4 is a partially enlarged view of Fig. 3 showing a connection member;

Fig. 5 is a partially enlarged view for illustrating the structure and function of a bimetallic strip;

Fig. 6 is a conceptual view illustrating a method for supporting the light emission tube;

Fig. 7A is a partially enlarged perspective view showing another example of the connection member;

Fig. 7B is a sectional view taken along a line VII-VII of Fig. 7A;

Fig. 8A is a partially enlarged perspective view showing still another

example of the connection member; and

Fig. 8B is a sectional view taken along a line VIII-VIII of Fig. 8A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] The inventors of the present invention found that when a high-pressure discharge lamp was used at a high operation pressure in a horizontal lighting posture, a breakage of the light emission tube of the lamp such as cracking was apt to occur immediately after the lamp was switched from an on status to an off status. Further, the inventors analyzed the thermal stress that caused the breakage, as described below in detail. The present invention is based on new findings obtained by the analysis. The increase in the pressure and temperature at the starting of the lamp, i.e., at the time of switching the lamp from the Off status to the on status, depends on the evaporation of sealed metals, and thus the increase is sufficiently moderate. However, at a high operation pressure in a horizontal lighting posture, abrupt temperature drop occurs immediately after the lamp is turned off or at the time of switching from the on status to the off status.

[0021] Fig.1 shows a temperature distribution of a light emission tube 1 of a metal halide lamp, which is a kind of high-pressure discharge lamp, during the light emission tube 1 is stably emitting the light. The light emission tube 1 is made of a ceramic material principally made from alumina (Al_2O_3). Sealed metals including mercury and metal halides are sealed in the light emission portion 1a as well as a rare gas serving as a buffer gas. The operation pressure is in the range of 10 to 15 Pa. Further, the light emission tube 1 is in a lighting posture (horizontal lighting

posture) where an imaginary straight line connecting a pair of electrodes 2A and 2B disposed in the light emission tube 1 or the axis line L thereof extends in a nearly horizontal direction. The light emission tube 1 is supported so that it can thermally expand in the direction of the axis line L extending in the horizontal direction but its displacement in a direction perpendicular to the axis line L including a vertical direction is restricted.

[0022] In Fig. 1, the higher a density of the dots provided in each region defined by isothermal lines T is, the higher the temperature in the region is. Since part of electric power to be supplied is consumed as thermal energy, the inside of the light emission portion 1a is heated at a high temperature of nearly 1,100℃. Further, since the lighting posture is horizontal, a temperature difference of nearly 100℃ occurs between the upper portion and the lower portion of the light emission tube 1. Specifically, although the temperature at the upper portion of the inner wall face of the light emission tube 1 designated by a point t1 is about 1,070℃, the temperature at the lower portion of the inner wall face of the light emission portion 1a designated by a point t2 is about 930℃. The temperature difference in the light emission portion 1a occurs as the result of a convection phenomenon in a high-temperature and high-pressure state due to a large amount of sealed metals filled in the light emission portion 1a. Therefore, the higher the pressure in the light emission portion 1a during lighting is, the larger the temperature difference is.

[0023] Fig. 2 shows a calculation result of stresses generated in various portions of the light emission portion 1a when the light emission portion 1a illuminating in such a high-temperature and high-pressure status was

turned off by a simulation using the finite-element method. Specifically, Fig. 2 shows a distribution of the thermal stresses generated in the portions of the light emission portion 1 at a room temperature when the temperature distribution shown in Fig. 1 is changed in accordance with a condition which simulates actual measurement values of temperature decreases immediately after turning off. In Fig. 2, the higher the density of the dots provided in each region divided by constant stress lines P is, the larger the thermal stress in the region is. As clearly shown in Fig. 2, the largest tensile stress is generated in the upper portion of the inner wall face among the various portions of the light emission tube 1. The tensile stress at a point p1 in the uppermost portion of the inner wall face is the maximum (111 MPa). The tensile stress decreases in the lower portions. For example, the tensile stress at a point p2 in the vertically central portion of the inner wall face is 30 MPa. Further, a compression stress is generated on the lower side of the inner wall. For example, a compression stress of -40 MPa is generated at a point p3 in the lowermost portion of the inner wall face. As indicated by arrows M1 and M2 in Fig. 2, the tensile stress is generated in the directions of the side tube portions 1b and 1c of the light emission tube 1 (in the direction of the axis line L). The portion wherein the tensile stress is generated corresponds to a portion wherein the light emission tube is broken in actual lamp strength tests.

[0024] As discussed above, it is found that when a high-pressure discharge lamp is used at a high operation pressure in a horizontal lighting posture, a large tensile thermal stress is generated in the upper portion of the light emission tube at the time of switching the lamp from the on status

to the off status, and that the thermal stress causes the breakage of the light emission tube.

[0025] Then, an embodiment of the present invention will be described below referring to the accompanying drawings. Fig. 3 shows a metal halide lamp as a high-pressure discharge lamp according to an embodiment of the present invention. A light emission tube 1 comprises a light emission portion 1a having a elongated hollow shape, a pair of side tube portions 1b and 1c extended from ends of the light emission portion 1a, and a pair of electrodes 2A and 2B. Tips of the electrodes 2A and 2B are exposed to the inside of the light emission portion 1a. The side tube portions 1b and 1c extend along an imaginary straight line connecting the electrodes 2A and 2B or along the axis line L. In this embodiment, the light emission portion 1a and the side tube portions 1b and 1c are made of a ceramic material principally made from alumina (Al_2O_3). The base ends of the electrodes 2A and 2B pass through the narrow tubes 1d and are guided to the outside of the light emission tube 1. An outer tube 1 is provided so as to enclose the light emission tube 1.

[0026] The electrical connection structure of the lamp will be described below. The base end of the electrode 2A on the right side in the figures is connected to a support member 3, whereas the base end of the electrode 2B in the left side is connected to a deformable member 4. Further, the support member 3 is connected to a wire frame 5, whereas the deformable member 4 is connected to a wire frame 6. The wire frames 5 and 6 are connected to an external lighting circuit (not shown) through a lamp base 7.

[0027] Sealed metals serving as light emission materials such as

mercury and a rare gas serving as a buffer gas such as metal halides are filled in the light emission portion 1a. The pressure in the light emission portion 1a during lighting, that is, the operation pressure, is in the range of 10 to 15 MPa. Further, the lighting posture of the lamp is horizontal. Specifically, the metal halide lamp is arranged so as to take a lighting posture where the axis line L connecting the pair of electrodes 2A and 2B elongates in a nearly horizontal direction.

[0028] Next, the support structure of the light emission tube 1 will be described below. The wire frame 5 of the two wire frames extends from the lamp base 7 in the horizontal direction by passing along the lower side of the light emission tube 1. A tip end of the wire frame 5 is fixed to a dinple portion 21a of the outer tube 21. The other wire frame 6 extends from the lamp base 7 in the horizontal direction. A tip end of the wire frame 6 is positioned near the side tube portion 1c of the light emission tube 1. Further, the tip end of the wire frame 6 is positioned higher than the light emission tube 1. The base end of the electrode 2A on the right side is mechanically supported by the wire frame 5, and the base end of the electrode 2B on the left side is mechanically supported by the wire frame 6.

[0029] Generally, the light emission tube 1 expands due to thermal expansion when the lamp is stably lighting comparing to when the lamp is cold. This thermal expansion of the light emission tube 1 is the largest in the horizontal direction (in the direction of the axis line L). The light emission tube 1 is supported so that the stress generated by the thermal expansion in the light emission tube 1 during lighting is relieved. First, corresponding to the base end of the electrode 2B on the left side of the

figure, the deformable member 4 and a support member 8, both extending in the vertical direction, are provided. The deformable member 4 is made of a material being conductive and deformable relatively freely such as a stranded wire made of a conductive material. An upper end of the deformable member 4 is welded to the wire frame 6 at the connection point 21, whereas its lower end is welded to the base end of the electrode 2B at the connection point 22. An upper end of the support member 8 is welded to the wire frame 6 at the connection point 17, whereas its lower end is provided with a ring-shaped portion 8a. The base end of the electrode 2B is inserted into the ring-shaped portion 8a but not fixed to the ring-shaped portion 8a. On the other hand, corresponding to the base end of the electrode 2A on the right side of the figure, the support member 3 extending in the vertical direction is provided. The lower end of the support member 3 is welded to the wire frame 5 at the connection point 20. The base end of the electrode 2A is welded to the support member 3 at the connection point 10. Because the left electrode 2B is inserted into the ring-shaped portion 8a and the deformable member 4 is deformable, the electrode 2B can be displaced in the direction of the axis line L. However, the displacement of the electrode 2B in a direction perpendicular to the horizontal direction (including the vertical direction) is restricted by the ring-shaped portion 8a. On the other hand, because the right electrode 2A is fixed to the support member 3, its displacement is restricted in the direction of the axis line L and in a direction perpendicular to the horizontal direction. Therefore, the light emission tube 1 can expand in the horizontal direction along the axis line L. Although the expansion relives the stress generated in the light

emission tube 1, the displacement in a direction perpendicular to the horizontal direction is restricted.

[0030] When the light emission tube 1 is assumed to be a beam, its right end is a fixed end fixed to the support member 3 and its left end is a rotational end. At the rotational end, only the displacement in the direction perpendicular to the axis line is restricted by the ring-shaped portion 8a.

[0031] Next, structures for relieving the thermal stress generated in the light emission tube 1 at the above-mentioned turning-off of the lamp will be described below with reference to Figs. 3 to 5.

[0032] Support shafts 11 and 12, each extending upward in the vertical direction, are connected to the wire frame 5. The support shaft 11 is disposed under the side tube portion 1b on the right side of the figure. Its lower end is welded to the wire frame 5 at the connection point 20, and its upper end is opposed to the side tube portion 1b with a clearance therebetween. On the other hand, the support rod 12 is disposed under the side tube portion 1c on the left side of the figure. Its lower end is welded to the wire frame 5 at the connection point 19, and its upper end is opposed to the side tube portion 1c with a clearance therebetween.

[0033] Fixtures or connection members 13 and 14 are respectively attached on the side tube portions 1b and 1c. Referring to Fig. 4, the connection member 14 is formed of a band-shaped metal plate and comprises an annular portion 14a attached so as to be wound around the outer circumferential face of the side tube portion 1c and a fixed portion 14b extending downward from the annular portion 14a. The annular portion

14a is wound obliquely around the side tube portion 1c. A contact position 14c of the annular portion 14a making contact with the upper portion of the side tube portion 1c is positioned inwardly with respect to the other contact position 14d of the annular portion 14a making contact with the lower portion of the side tube portion 1c. In other words, the contact position 14c is positioned on the side of the light emission portion 1a. The annular portion 14a is attached so as not to be displaced easily from the side tube portion 1c, whereby the contact positions 14d and 14c are stationary. The connection member 13 is similar to the connection member 14 in material, shape, and the installation posture with respect to the side tube portion 1b.

[0034] The support shafts 11 and 12 are respectively connected to the connection members 13 and 14 by bimetallic strips 15 and 16 serving as thermal-stress generation members. Referring to Fig. 5, a base end of the bimetallic strip 16 is welded to the support rod 12, and its tip end is welded to the fixed portion 14b of the connection member 14. The bimetallic strip 16 comprises a plate (high thermal expansion plate 31) made of an alloy material having a high thermal expansion coefficient and a plate (low thermal expansion plate 32) made of an alloy material having a low thermal expansion coefficient, the two plates being laminated together. The bimetallic strip 16 has a thermal deformation effect. In other words, when the temperature rises, the deformation of the high thermal expansion plate 31 becomes larger than that of the low thermal expansion plate 32, thereby the bimetallic strip 16 is bent inward on the side of the low thermal expansion plate 32. In this embodiment, the bimetallic strip 16 is disposed so that the low thermal expansion plate 32 is positioned above the high

thermal expansion plate 31 in the vertical direction, that is, on the side of the light emission tube 1. Further, the high thermal expansion plate 31 and the low thermal expansion plate 32 are selected with respect to material, shape and dimensions, and fixed to the support rod 12 and the connection member 14 so that the bimetallic strip 16 is bent inward on the side of the low thermal expansion plate 32 by the heat radiated from the light emission tube 1 during stable lighting as indicated by solid lines A in Fig. 5. The structure and installation posture of the bimetallic strip 15 connected to the support shaft 11 and the connection member 13 are similar to those of the bimetallic strip 16.

[0035] In the metal halide lamp according to the embodiment, its lighting operation pressure is high (10 to 15 MPa), and its lighting posture is horizontal. Hence, as described with reference to Figs. 1 and 2, a large tensile thermal stress is generated in the upper portion of the light emission tube 1 at the time of switching the lamp from the on status to the off status. This thermal stress is exerted on the light emission tube 1 as a deformation force for deforming the light emission portion 1a into an arch shape protruding upward in the vertical direction as schematically indicated by a broken line in Fig. 6.

[0036] On the other hand, immediately after the metal halide lamp is turned off, the heat radiated from the light emission tube 1 abruptly decreases to cause temperature drop. Thus, the high thermal expansion plate material 31 of each of the bimetallic strips 15 and 16 starts shrinking abruptly. Referring to Fig. 5 again, if the bimetallic strip 16 were not welded to the connection member 14, the bimetallic strip 16 would be

deformed abruptly into the straight-line shape indicated by broken lines B due to the temperature drop. However, since both ends of the bimetallic strip 16 are welded to the support rod 12 and the connection member 14 so as to restrict such deformation in reality, the bimetallic strip 16 is hardly deformed from the shape indicated by solid lines A, resulting in that a thermal stress is generated. This thermal stress generated in the bimetallic strip 16 is exerted on the side tube portion 1c of the light emission tube 1 via the connection member 14 as a force as indicated by an arrow Y. Also referring to Fig. 3, a thermal stress is also generated in the bimetallic strip 15 due to the above-mentioned temperature drop immediately after the lamp is turned off. This thermal stress is exerted on the side tube portion 1b of the light emission tube 1 via the connection member 13 as a force as indicated by an arrow X. The directions of the forces X and Y exerted on the side tube portions 1b and 1c due to the thermal stresses generated in the bimetallic strips 15 and 16 are obliquely downward, more specifically, downward in the vertical direction with respect to the side tube portions 1b and 1c and outward (away from the light emission portion 1a) with respect to side tube portions 1b and 1c. Therefore, as schematically indicated by an alternate long and short dash line, these forces X and Y are exerted on the light emission tube 1 as forces for deforming the light emission portion 1a into an arch shape protruding downward in the vertical direction, thereby generating a compression stress in the upper portion of the inner wall face of the light emission tube 1. In other words, the forces X and Y cause a deform of the light emission tube 1 in a direction opposite to the direction of the deformation (indicated by the broken line in Fig. 6) of the

light emission tube 1 due to the thermal stress generated in the light emission tube 1 at the time of switching the lamp from the on status to the off status. Accordingly, the tensile thermal stress generated on the inner wall face of the light emission portion 1a immediately after the light emission tube 1 is turned off, in particular, the thermal stress in the uppermost portion (at the point t1 in Fig. 2) of the inner wall face of the light emission portion 1a, is effectively relieved by the forces X and Y exerted on the light emission tube 1 from the bimetallic strips 15 and 16 through the connection members 13 and 14.

[0037] Figs. 7A and 7B show another example of the connection member. The annular portion 13a of the connection member 13 is crimped onto the side tube portion 1b, thereby the entire inner face of the annular portion 13a tightly contacts with the outer circumferential face of the connection member 13. Further, the lower end of the fixed portion 13b is bent, and the bent portion is welded to the upper face of the bimetallic strip 15. Since the connection member 13 is firmly fixed to the side tube portion 1b by crimping the annular portion 13a onto the side tube portion 1b, the thermal stress generated in the bimetallic strip 15 at the turning off the lamp is securely or reliably transmitted to the light emission tube 1 via the connection member 13. A structure similar to this may also be applied to the other connection member 14 (see Fig. 3).

[0038] Figs. 8A and 8B show still another example of the connection member. An annular groove 1d is formed on the outer circumferential face of the side tube portion 1b. The annular portion 13a of the connection member 13 is fitted into the groove 1d. The annular portion 13a is crimped

onto the side tube portion 1b. Since the annular portion 13a is fitted into this groove 1d, the annular portion 13a is securely prevented from being displaced with respect to the side tube portion 1b in the direction of the axis line L. Therefore, the thermal stress of the bimetallic strip 15 is more reliably or securely transmitted to the light emission tube 1. A structure similar to this may also be applied to the other connection member 14 (see Fig. 3).

[0039] The relief of the tensile stress in the vertically upper portion of the light emission portion 1a configured as described above is more effective as the pressure in the light emission portion 1a is higher. The relief is particularly effective in the case when the inner pressure at the turning-on time of the light emission portion 1a is 10 MPa (about 10 atms). For raising the pressure in the light emission portion 1a to equal to or higher than 10 MPa at during the lamp is lighting, a mixture of PrI_3, CsI and NaI can be adopted as substances to be sealed.

[0040] There are some points to be considered in design so that the effect of relieving the tensile stress of the light emission portion 1a configured as described above is produced sufficiently. A first point is that the wire frames 5 and 6, the support members 3 and 8, and the support shafts 11 and 12 should have high strength. In order that the thermal stresses generated in the bimetallic strips 15 and 16 are effectively exerted as the forces X and Y for relieving the tensile thermal stress of the light emission portion 1a, members around the light emission portion 1a, i.e., the wire frames 5 and 6, the support members 3 and 8, and the support shafts 11 and 12 are required to be designed with respect to material, shape, and dimensions so as not to

be deformed easily. In the case when stainless steel is used as a conductive metal material, its diameter is desired to be equal to or more than 0.5 mm. Similarly, it is needless to say that strong welding is necessary at the connection points 10 and 17 through 20 so that the members used for support do not easily become unsteady.

[0041] A second point relates to cooling speed of the bimetallic strips 15 and 16. The alumina or quartz constituting the light emission tube 1 is higher in specific heat and lower in heat conductivity comparing with metallic materials constituting members such as the support shafts 11 and 12, and the bimetallic strips 15 and 16. Thus, when the light emission tube 1 is switched from the on status to the off status, the cooling speed of the bimetallic strips 15 and 16 is sufficiently higher than that of the light emission tube 1. However, as a measure for further safety, the support shafts 11 and 12 may be provided with a structure, such as a cooling fin, having a large surface area so that heat radiation from the support shafts 11 and 12 is accelerated, thereby increasing cooling speed of the support shafts 11 and 12 immediately after the turning off.

[0042] In addition, the above-mentioned embodiment is provided with the support shafts 11 and 12 designed specially for supporting the bimetallic strips. However, in the case when no sufficient space is obtained in the lamp, the support members 3 and 8 for the light emission tube 1 may also be used to support the bimetallic strips 15 and 16.

[0043] Further, Although the bimetallic strips are adopted as thermal-stress generation members for generating thermal stresses due to the temperature change in the above-mentioned embodiment, the thermal-

stress generation members may be made of a single metal material having a required expansion coefficient depending on the shape of the light emission tube, and the magnitude and direction of a compressive stress required to be exerted on the light emission tube. In other words, the thermal-stress generation members should only generate thermal stresses due to the temperature change of the light emission portion 1a, and the thermal stresses should only act as forces in the directions for relieving the thermal stress generated in the light emission portion 1a.

[0044] Furthermore, in the above-mentioned embodiment, the ceramic material is used as the material of the light emission tube 1. However, it is needless to say that the present invention is applicable even when other materials generally used, such as quartz glass, are used for the light emission tube 1. In the case when ceramic having a high expansion coefficient is used for the light emission tube 1, the light emission tube 1 has a relatively high possibility of breakage, such as cracking. Thus, the present invention is preferably applicable in the case when the material of the light emission tube 1 is ceramic.

[0045] Although the present invention has been fully described in conjunction with preferred embodiments thereof with reference to the accompanying drawings, various changes and modifications are possible for those skilled in the art. Therefore, such changes and modifications should be construed as included in the present invention unless they depart from the intention and scope of the invention as defined by the appended claims.